PIP-II Requirements Management Process

Lidija Kokoska/ Fermilab

PIP-II Technical Workshop

December 2nd, 2020

A Partnership of:
- US/DOE
- India/DAE
- Italy/INFN
- UK/UKRI-STFC
- France/CEA, CNRS/IN2P3
- Poland/WUST

Background Bio

- Lidija Kokoska
  - Organization: PIP-II Technical Integration Office
  - Role: PIP-II Project Engineer since start of 2020 (1 year)
    - Responsible for coordinating PIP-II project-wide systems engineering processes
- Other Roles
  - 8 years at Fermilab
    - Deputy Department Head of APS-TD Magnet Test & Instrumentation Department (3 years)
    - Fermilab Mechanical Engineer (8 years)
  - 5 years in private industry
    - High Pressure Filtration Equipment for Aerospace, Renewable Energy, and Oil & Gas Industries
- lkokoska@fnal.gov

Overview

- PIP-II Requirements Management Plan
- Requirement Types
- Requirement Development & Guidelines
- Requirement Validation & Review
- Requirement Traceability & Metadata
- Requirements Verification
- Approval & Revision
- Additional Requirements Management Documents
- Partner Requirements

PIP-II Requirements Management Plan

Fermi National Accelerator Laboratory

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PIP-II Requirements Management Plan

Document number: ED0008235 Rev. A

Document Approval

Signatures Required	Date Approved
Originator: Integration Team	-
Approver: Alex Martinez, Integration Coordinator	Approved in TC
Approver: Jeremiah Holzbauer, SRF Coordinator	Approved in TC
Approver: Allan Rowe, In-Kind Technical Integration Coordinator	Approved in TC
Approver: Lidija Kokoska, Project Engineer	Approved in TC
Approver: Eduard Pozdeyev, Project Scientist	Approved in TC
Approver: Arkadiy Klebaner, Technical Director	Approved in TC

Revision History

Revision	Date of Release	Description of Change
-	7/12/2019	Initial Release

PIP-II Requirements Management Plan

Table of Contents

"The Requirements Management Plan provides a process to control, identify, manage, review, approve, release, and revise PIP-II requirements for the PIP-II Work Breakdown Structure (WBS) systems ."

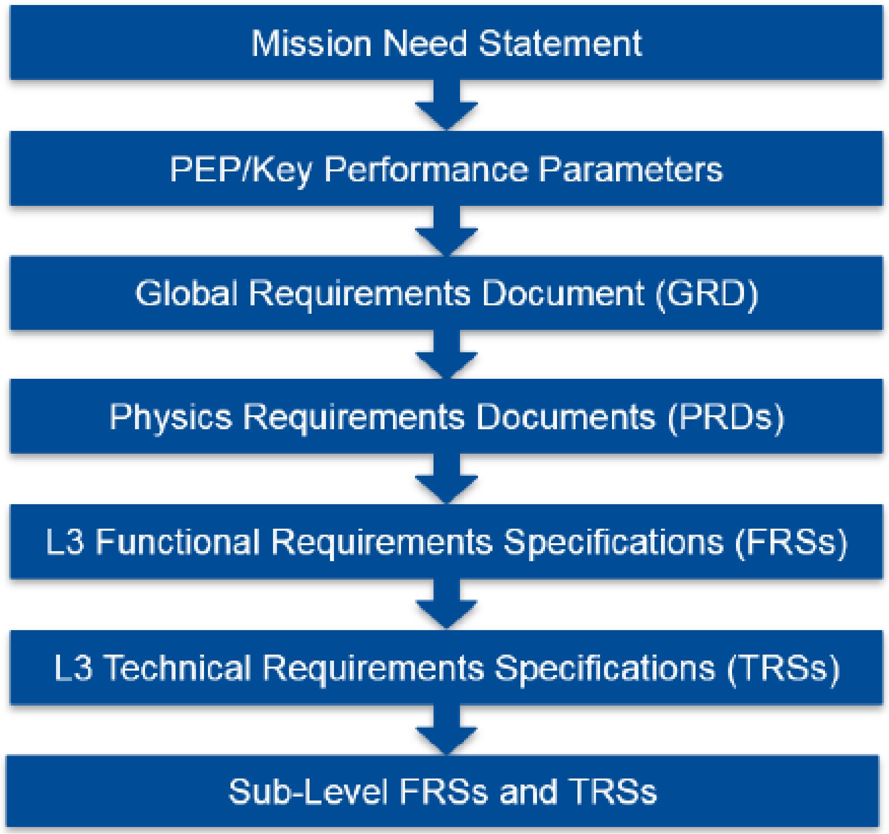
Requirement Types and Flowdown

- Requirements Framework derived from <u>Mission Need Statement</u>:

“The current beam power of 700 kW is insufficient to meet the P5 goal of delivering 120 MW-kton-years by 2035. Increasing the beam power to 1.2 MW would roughly double the DUNE data-taking rate, significantly increasing the competitive edge of the experiment by halving the time it would take to achieve significant scientific results. This in turn raises the probability that the U.S. neutrino physics program will continue to outperform the Japanese program – the closest competitor – in the 2020s. This need for higher proton beam power comes at a time when many components of the existing Fermilab accelerator complex that delivers beam to the Main Injector - especially the linear accelerator (Linac) and the Booster - are approaching 50 years old. Thus, a proton beam power upgrade is proposed to meet two main capability gap and mission need goals:

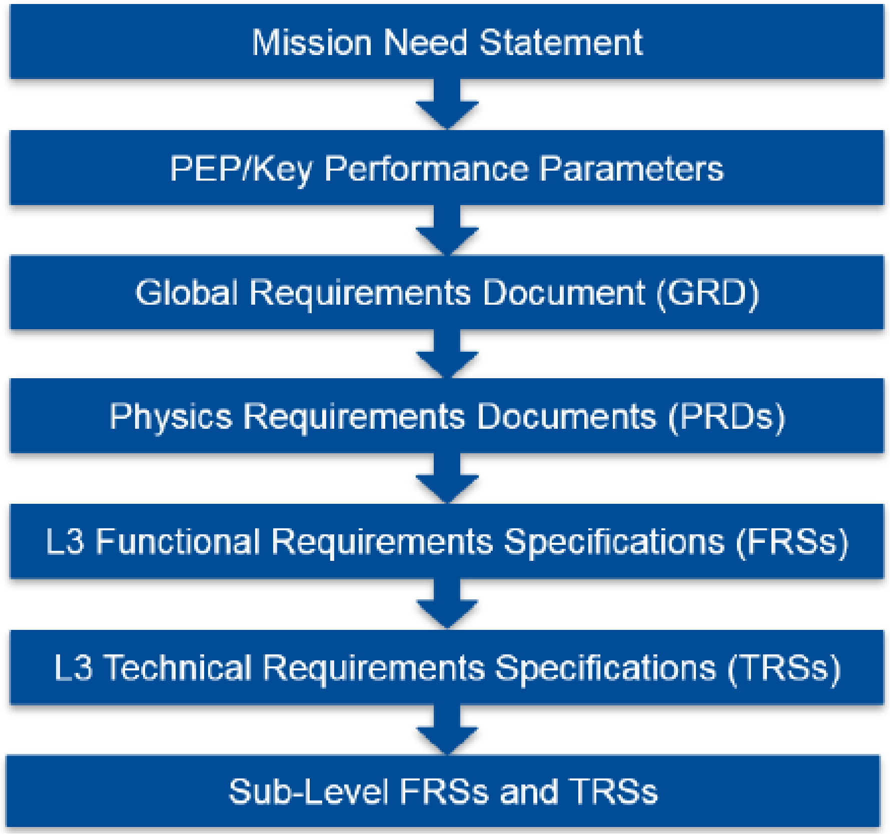
1. To reduce the time for LBNF/DUNE to achieve world-first results.

2. To sustain high reliability operation of the Fermilab accelerator complex.”



Requirement Types & Flowdown

- GRD – Global Requirements Document (ED0001222)
  - Highest project-level requirements document
  - Specifies performance requirements derived from Key Performance Parameters (KPPs) defined in Mission Need Statement
- PRDs – Physics Requirement Documents
  - Summary parameters and configuration definitions (not only related to physics)
  - Top Level requirements that cross boundaries between multiple systems
- FRSs – L3 Functional Requirements Specifications
  - Contains project needs or requested behavior of L3 system
  - Specifies core functions for system
- TRSs – L3 Technical Requirements Specifications
  - Contains technical parameters that the L3 system or complex component must fulfill
  - Impact the overall sub-systems' performance
- Sub-Level FRSs and TRSs
  - Managed at the discretion of the L2 and L3 manager

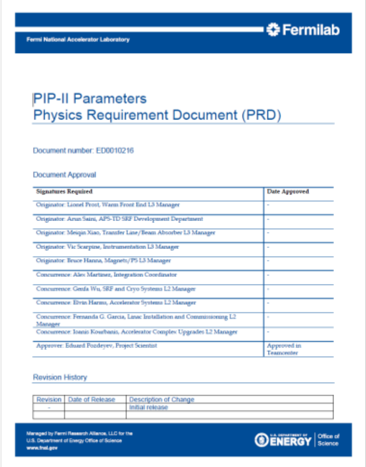


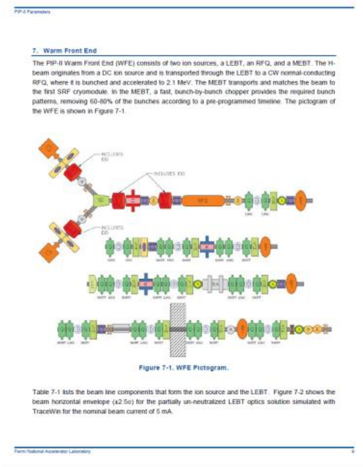
PRDs

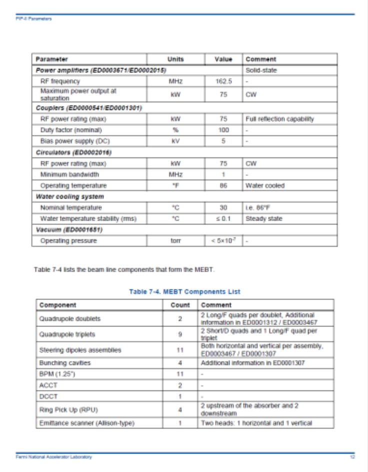
- Physics Requirements Documents derived from the PIP-II Preliminary Design Report
- Establish a traceable link to lower level FRSs and TRSs
- Impact beam or machine performance
- Contains basic parameters and configurations of the overall design of PIP-II accelerator and complex

Table 4-1. List of Physics Requirements Documents (PRDs)

#	Physics Requirement Document	Teamcenter #
1	PIP-II Parameters PRD	ED0010216
2	PIP-II Linac RF System PRD	ED0010220
3	SRF Cavity Parameters PRD	ED0010221
4	RT Linac RF Cavity Parameters PRD	ED0010222
5	Accelerator Upgrades RF Cavity Parameters PRD	ED0010223
6	Controls PRD	ED0010225
7	Magnet PRD	ED0010226
8	Vacuum PRD	ED0010228
9	Timing system PRD	ED0010229
10	Beam Instrumentation PRD	ED0010230
11	Misalignment Tolerances PRD	ED0010231
12	Machine Protection System PRD	ED0010232
13	Beam Dumps and BTL Collimators PRD	ED0010235
14	Booster Dampers PRD	ED0010236
15	Booster Collimators PRD	ED0010237
16	MI Gamma_t jump PRD	ED0010238
17	Injection into Booster PRD	ED0010242
18	Beam Loss PRD	ED0010243
19	Cryogenic Heat Load PRD	ED0008200







FRS Development & Guidelines

- FRS Guidance Document and Template (ED0007977)
- FRS required for each individual L3 sub-system
- Individually listed in tabular form
- Unique identifier assigned to individual requirement (F-WBS#-xxx)
- “Shall” term used to develop definitive statements

Table 5-1. Example FRS Format

Requirement #	Requirement Statement
F-121.2.03.02-C001	The SSR1 cryomodule shall contain Beam Position Monitoring systems adjacent to each focusing element.
F-121.2.03.02-C002	The SSR1 cryomodule internal wiring shall be of a material and size that minimizes heat load to the internal systems.
F-121.2.03.02-C003	The SSR1 cryomodule shall have thermometry to allow for monitoring and control under all expected operational scenarios.
F-121.2.03.02-C004	The SSR1 cryomodule shall have pressure instrumentation to allow for monitoring and control under all expected operational scenarios.
F-121.2.03.02-C005	The SSR1 cryomodule shall have vacuum instrumentation to allow for monitoring and control under all expected operational scenarios.
F-121.2.03.02-C006	The SSR1 cryomodule shall have cryogen level instrumentation to allow for monitoring and control under all expected operational scenarios.
F-121.2.03.02-C007	The SSR1 cryomodule shall have internal magnetic field probes to allow for monitoring and control under all expected operational scenarios.

TRS Development & Guidelines

- New TRS Guidance Document and Template (ED0012980)
- TRS required for each individual L3 sub-system or as a set of TRSs written at device level
- Background context and justification narrative allowed, but requirement individually listed.
- Requirements summary table listed as separate meta-data sheet.
- Unique identifier assigned to individual requirement (T-ED#-xxx)
- "Shall/will/should" terms used to develop definitive statements

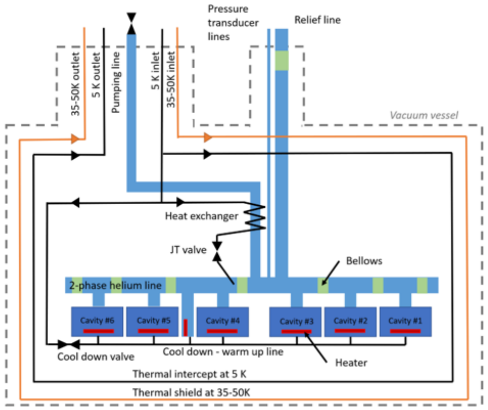


Figure 5.2-1 – Basic schematic of cryogenic circutis.

5.2.1. Cryogenic System Pressure Ratings

Anchoring and thermal contraction of each cryogenic circuit will consider worst case pressure, temperature and alignment extremes.

T-ED0009659-A001: Each cryogenic circuit identified in Table 5.2 shall be capable of cool-down and warm-up to their noted design temperatures, independent of the state of other circuits.

T-ED0009659-A002: The cryogenic circuits shall be capable of the associated MAWP at the noted temperature as specified in Table 5.2.

Table 5.2 CRYOGENIC SYSTEM PRESSURE RATINGS

System	Warm MAWP	Cold MAWP
2 K, low pressure	2.05 bar@ 300K	4.1 bar @ 2 K
2 K, positive pressure piping	20 bar @ 300K	20 bar @ 2 K
5 K piping	20 bar @ 300K	20 bar @ 5 K
35-50 K piping	20 bar @ 300K	20 bar @ 50K
Insulating vacuum	1 bar @ 300K (external) vacuum inside	N/A

TRS Requirement Information				Impacted Stakeholders			Upward Traceability					
TRS Name	TRS TC#	Requirement ID	TRS Statement	Impacted L3 System or Stakeholder Organization	Assigned Stakeholder Name	Comments from Stakeholder	Driving Document Type	Document Name	Document Number	Requirement Number	Sub-Heading	Driving Requirement Statement
							(sub-section, if applicable)					
Techncia	ED00XXX	T-ED00XXX-A001	Device XXXYYYZZZ shall				FRS					

Requirement Validation & Review

- Requirements to be validated and reviewed against stakeholder expectations
- Assures the given design will meet the system and project objectives
- Performed through the project lifecycle as requirements change (ideally prior to design reviews)
- Ensures requirements are:
  - Achievable
  - Clear
  - Complete
  - Consistent
  - Singular
  - Traceable
  - Verifiable

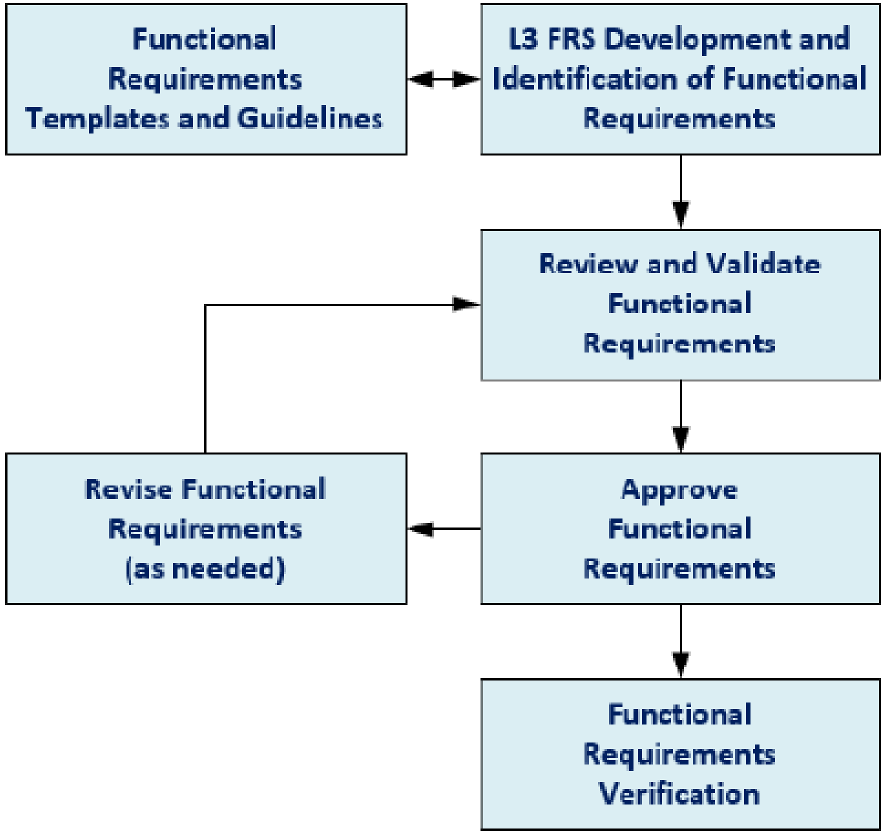


Figure 6-1. Functional Requirements Management Process

Requirement Traceability & Metadata

- Requirements traceability is done at the L3 functional requirement level
- Meta-Data Sheets for each L3 FRS
  - Lists all the FRS requirements individually with the unique requirements identifier
  - Displays the requirement description
  - Includes sections for documenting upper GRD and PRD traceability
  - Includes a section for documenting lower TRS traceability
  - Includes a section for verification information (description, method, timeline, etc.)

PIP-II High Power RF FRS			ED0008023	FRS Metadata Datasheet					
Tier 1 Upward Traceability (GRD)			Tier 2 Upward Traceability			FRS Existing Requirement Information			
T1 Document Name	T1 TC #	Tier 1 Statement	T2 Document Name	T2 TC #	Tier 2 Statement	Requirement #2	Sub-Heading3	Requirement Statement4	TR
Global Requirements Document (GRD)	ED0001222	Requirement I4 states the reliability requirement for the SRF Linac.	Best Practices	None	Best practice for equipment protection.	F-121.3.03-C001	Self-Preservation Requirements	The HPRF system amplifiers shall not re-enable the output after being disabled by a trip until the trip is RESET.	325 Am
Global Requirements Document (GRD)	ED0001222	Requirement I4 states the reliability requirement for the SRF Linac.	Best Practices	None	Best practice for equipment protection.	F-121.3.03-D001	Cavity Protection Requirements	The HPRF system amplifiers shall accommodate an input signal that will disable the output of the amplifier in a fail-safe manner.	TB
No further upward traceability	None	NA	Machine Protection System PRD	ED0010220	Section 5 of the MPS PRD on system architecture discuss signal inputs to the MPS such as RF status.	F-121.3.03-D001	Cavity Protection Requirements	The HPRF system amplifiers shall provide an output signal that represents the output disabled state of the amplifier (for MPS).	TB

	TRS Downward Traceability			Requirement Verification				
	TRS Name	TRS TC #	TRS Statement	Verification Method	Verification Document #	Verification Description	Verification Timeframe	Verification Status
not ESET.	325 MHz 7 kW SS RF Amplifier TRS	ED0004290	Section 7.3 on internal protection, item X lists the requirement regarding the RESET command.	Demonstration/Test	Commissioning documents	Design verification will be done during the review cycle and finally during commissioning.	During commissioning	Open
will n a	TBD	TBD	TBD	Demonstration/Test	Commissioning documents	Design verification will be done during the review cycle and finally during commissioning.	During commissioning	Open
sents plifier	TBD	TBD	TBD	Demonstration/Test	Interface documentation	Design verification will be done during the review cycle and finally during commissioning.	During commissioning	Open

Requirement Traceability & Metadata

- FRS's are centerpiece of requirements management
- FRS's bridge gap between higher level project requirements & lower-level design technical requirement

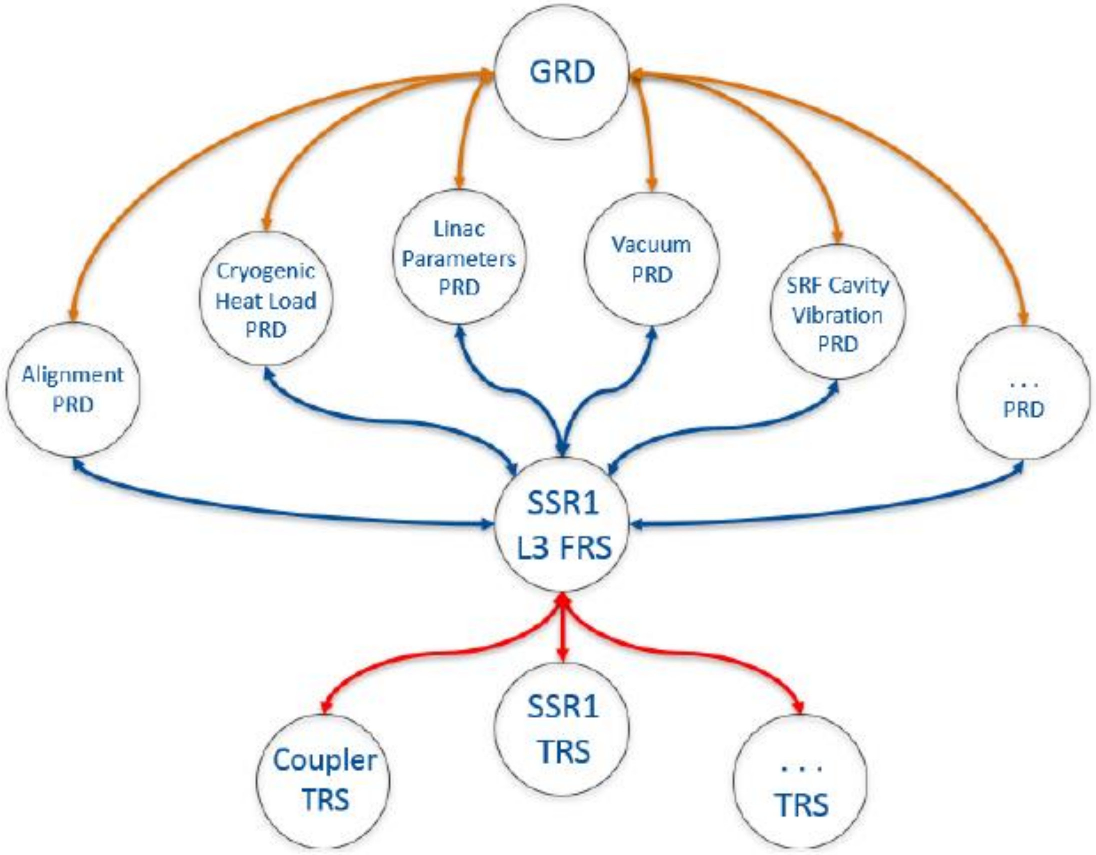


Figure 7-1. Example Traceability Flow Chart for SSR1

Requirement Traceability & Metadata

- GRD & PRD traceability upstream of FRS
  - “Self-Derived” or “Best Practice” noted where there is no direct traceability of FRS origin
- TRS traceability downstream of FRS
  - “Self-Derived” or “None” noted where these is no direct traceability of TRS to FRS

- Verification Traceability:
  - Verification Method
  - Verification Document #
  - Verification Description
  - Verification Timeline
  - Verification Status

PIP-II High Power RF FRS			ED0008023	FRS Metadata Datasheet					
Tier 1 Upward Traceability (GRD)			Tier 2 Upward Traceability			FRS Existing Requirement Information			
T1 Document Name	T1 TC #	Tier 1 Statement	T2 Document Name	T2 TC #	Tier 2 Statement	Requirement #2	Sub-Heading3	Requirement Statement4	TR
Global Requirements Document (GRD)	ED0001222	Requirement I4 states the reliability requirement for the SRF Linac.	Best Practices	None	Best practice for equipment protection.	F-121.3.03-C001	Self-Preservation Requirements	The HPRF system amplifiers shall not re-enable the output after being disabled by a trip until the trip is RESET.	32 Am
Global Requirements Document (GRD)	ED0001222	Requirement I4 states the reliability requirement for the SRF Linac.	Best Practices	None	Best practice for equipment protection.	F-121.3.03-D001	Cavity Protection Requirements	The HPRF system amplifiers shall accommodate an input signal that will disable the output of the amplifier in a fail-safe manner.	TB
No further upward traceability	None	NA	Machine Protection System PRD	ED001022					

	TRS Downward Traceability			Requirement Verification				
	TRS Name	TRS TC #	TRS Statement	Verification Method	Verification Document #	Verification Description	Verification Timeframe	Verification Status
not ESET.	325 MHz 7 kW SS RF Amplifier TRS	ED0004290	Section 7.3 on internal protection, item X lists the requirement regarding the RESET command.	Demonstration/Test	Commissioning documents	Design verification will be done during the review cycle and finally during commissioning.	During commissioning	Open
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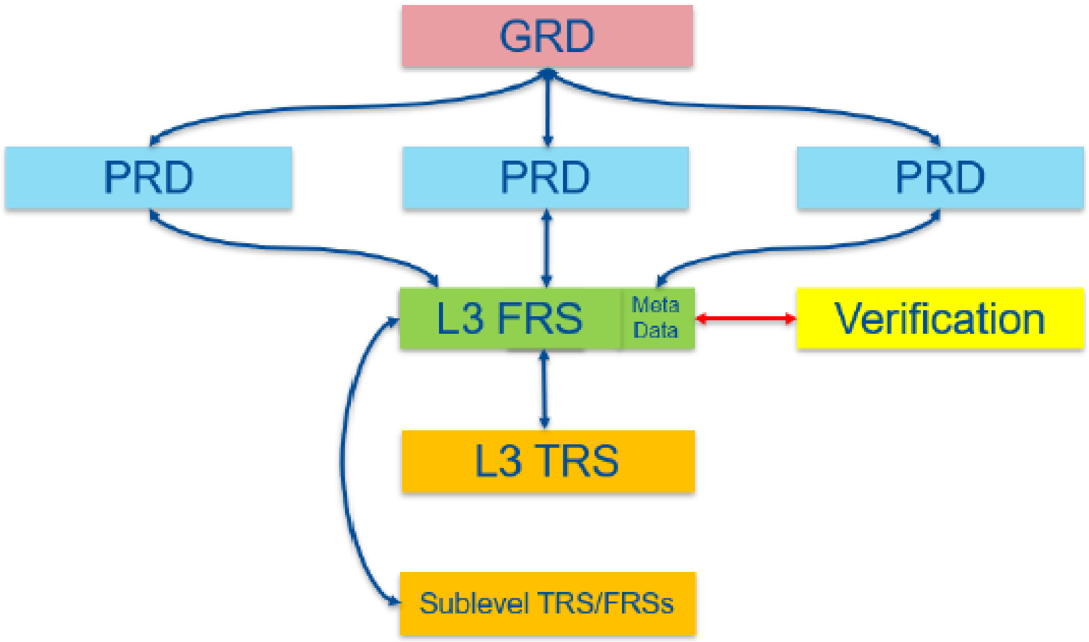
sents plifier	TBD	TBD	TBD	Demonstration/Test	Interface documentation	Design verification will be done during the review cycle and finally during commissioning.	During commissioning	Open

Requirements Verification

- Process that confirms the given design and implementation meets the functional requirements
- Verification performed in three ways:
  - Inspection
  - Demonstration/Test
  - Analysis
- Completed at various stages of the project
  - L3 FRSs reviewed for compliance at each review stage



Requirements Approval & Revision

- May occur at any time during the project lifecycle
- Change control required to assure:
  - Latest approved requirements are used
  - Changes aren’t made without authorization
  - Changes are traceable
  - Impact analysis on other systems is performed
- At a minimum, approval is required by L2M and impacted stakeholders

Additional Requirement Management Documents

- Occasionally additional documents are required for “customer” and “supplier” agreements:
  - PIP-II Cryogenic Heat Load Analysis (ED0008200) ➔ Cryoplant Requirements

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PIP-II Cryogenic Heat Load Analysis
Physics Requirement Document (PRD)

Document number: ED0008200, Rev. - B

Table 2: HWR cryogenic heat load summary

HWR	Each unit (W)					#	Total (W)				
	HTTS (40 K Supply/Return)	LTTS (4.5 K Return)	4.5 K Supply	2 K Isothermal	2 K Non-isothermal		HTTS (40 K Supply/Return)	LTTS (4.5 K Return)	4.5 K Supply	2 K Isothermal	2 K Non-isothermal
Cavity dynamic	0.00	1.00	0.0	0.80	0.00	8	0.0	8.0	0.0	6.4	0.0
Input coupler (dynamic)	5.90	0.60	0.0	0.09	0.00	8	47.2	4.8	0.0	0.7	0.0
Current leads (dynamic)	15.00	2.00	0.0	0.50	0.00	8	120.0	16.0	0.0	4.0	0.0
Beam (dynamic)	0.00	0.00	0.0	5.90	0.00	1	0.0	0.0	0.0	0.0	0.0
Input coupler (static)	2.60	1.60	0.0	0.06	0.00	8	20.8	12.8	0.0	0.5	0.0
Current leads (static)	6.00	9.00	0.0	1.50	0.00	8	48.0	72.0	0.0	12.0	0.0
Strongback hangers	0.00	0.00	0.0	0.05	0.00	6	0.0	0.0	0.0	0.3	0.0
Conduction beam line	0.20	0.10	0.0	0.10	0.00	2	0.4	0.2	0.0	0.2	0.0
Thermal shield	116.00	0.00	0.0	3.00	0.00	1	116.0	0.0	0.0	3.0	0.0
View ports	0.20	0.00	0.0	0.70	0.00	4	0.8	0.0	0.0	2.8	0.0
Relief line	1.00	0.00	0.0	0.50	0.00	1	1.0	0.0	0.0	0.5	0.0
Valves & Instrumentations	10.00	2.19	0.8	2.00	0.00	1	10.0	2.2	0.8	2.0	0.0
Helium manifold	0.00	0.00	0.0	5.00	0.00	1	0.0	0.0	0.0	5.0	0.0
Vacuum manifold	0.00	0.00	0.0	0.50	0.00	1	0.0	0.0	0.0	0.5	0.0
Slow tuner	0.00	0.00	0.0	0.05	0.00	8	0.0	0.0	0.0	0.4	0.0
Total dynamic							167.2	28.8	0.0	11.1	0.0
Total static							197.0	87.2	0.8	27.18	0.00

Additional Requirement Management Documents

- Occasionally additional documents are required for “customer” and “supplier” agreements:
  – PIP-II Room Data Sheet (ED0009544) ➔ CF Linac Complex Requirements

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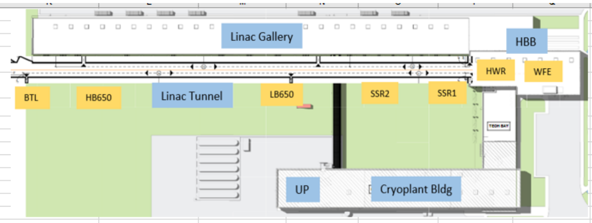
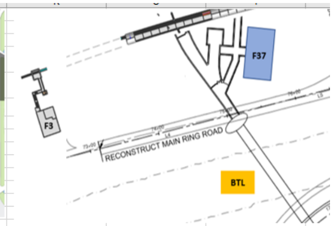
Room Data Sheet
PIP-II

= Denotes missing information
#N/A = These cells are automatically calculated, no input required
= Data cells not applicable





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										Level of Design		Spatial Requirements					Floor Requirements
Identifier	WBS Level 2	WBS ID	WBS Name	Space Designation Location	Sub-System	User Defined Sub-System	Component	Description	Quantity	Level of Design	Source of Requirements	Space Type	Length (in)	Width (in)	Height (in)	Weight (lbs)	Floor Flatne
DM-001	121.03	121.03.07	Controls	LG-BTL	Computers, Front End	Candidate for F37	Racks	Networking, permits etc.	3	Preliminary	Off the Shelf	Floor	30	24	60		
DM-002	121.03	121.03.08	SS	LG-BTL	Interlocks	Candidate for F37	Racks	ESS interface	1	Preliminary	Off the Shelf	Floor	30	32	96		
DM-003	121.03	121.3.06	Controls	BTL-F3 Building	PLC/LCW Controls	Candidate for F37	Racks, Rittal	Rittal half size cabinet (needs to remain at F3)	1	Preliminary	Off the Shelf	Floor	40	16	84		
DM-004	121.03	121.03.06	Vacuum	BTL-F3 Building	Ion Pump PS System	Candidate for F37	Racks	Bulk, Ion pump PS, gauge interface, network switch	2	Preliminary	Off the Shelf	Floor	30	24	60		
DM-005	121.03	121.03.09	Instrumentation	LG-BTL	BPM	Candidate for F37	Racks		2	Preliminary	Prototype-Testing	Floor	30	24	60		
DM-006	121.03	121.03.09	Instrumentation	BTL-F3 Building	BPM	Candidate for F37	Racks		1	Preliminary	Prototype-Testing	Floor	30	24	60		
DM-008	121.03	121.03.05	Magnets	BTL-F3 Building	Fast Dipole Switch	Candidate for F37	Racks	Pulse Magnet Power Supply	1	Conceptual	Expert Opinion	Floor	30	24	60		
DM-009	121.03	121.03.05	Magnets	LG-BTL	Fast Dipole Switch	Candidate for F37	Cables	Power Supply	8	Preliminary	Prototype-Testing						
DM-010	121.03	121.03.05	Magnets	LG-BTL	Fast Dipole Switch	Candidate for F37	Magnets	Power Supply	1	Conceptual	Expert Opinion						
DM-011	121.03	121.03.05	Magnets	BTL-F3 Building	Magnets, Dipole		Power Supplies	TeV PS	1	Preliminary	Expert Opinion	Floor	60	24	96	3500	
DM-012	121.03	121.03.05	Magnets	BTL-F3 Building	Magnets, C-dipole	Candidate for F37	Power Supplies	125KW Spange PS	1	Preliminary	Off the Shelf	Floor	62	44	89	3500	
DM-013	121.03	121.03.05	Magnets	BTL-Beamline Tunnel	Magnets, Dipole		Cables	Dipole cables	134	Preliminary	Off the Shelf						
DM-014	121.03	121.03.05	Magnets	BTL-Beamline Tunnel	Magnets, Dipole		Cables	Specialty magnet cables	18	Preliminary	Off the Shelf						
DM-015	121.03	121.03.05	Magnets	BTL-F3 Building	Magnets, Regular Quadrupole	Candidate for F37	Racks	Quadrupole Power Supplies	3	Preliminary	Off the Shelf	Floor	30	24	90		

ED0009544 PIP-II Room Data Sheet

	Power					
By Area Designation	**21638**		KVA	**19943**		kW
HBB	703		KVA	702		kW
HBB-Lower High Bay		456	KVA		456	kW
HBB-Upper High Bay		236	KVA		235	kW
HBB-Control Room		7	KVA		7	kW
HBB-Tech Support Space		0	KVA		0	kW
HBB-Computer Space		3	KVA		3	kW
HBB-Exterior Space		0	KVA		0	kW
LT	41		KVA	41		kW
LT-HWR		2	KVA		2	kW
LT-SSR1		3	KVA		3	kW
LT-SSR2		12	KVA		12	kW
LT-LB650		15	KVA		15	kW
LT-HB650		7	KVA		7	kW
LT-Upgrade*		2	KVA		2	kW
LG	12541		KVA	10922		kW
LG-General		66	KVA		66	kW
LG-HWR		158	KVA		146	kW
LG-SSR1		296	KVA		272	kW
LG-SSR2		1679	KVA		1526	kW
LG-LB650		3755	KVA		3236	kW
LG-HB650		4295	KVA		3702	kW
LG-Upgrade*		2101	KVA		1806	kW
LG-BTL		192	KVA		168	kW
LG-Exterior Space		0	KVA		0	kW
BTL	7		KVA	7		kW
BTL-Tunnel		0	KVA		0	kW
BAL-Beam Absorber		7	KVA		7	kW
BTL-F3 Building**	344		KVA	300		kW
F37	0		KVA	0		kW
Cryoplant Building	3247		KVA	3247		kW
Cold Box Station		135	KVA		135	kW
Warm Compressor Section		3110	KVA		3110	kW
Network Room/General DAQ		2	KVA		2	kW
UP	775		KVA	743		kW
Compressed Air		206	KVA		175	kW

	Power			
By System	**21638**	KVA	**19943**	kW
HWR	0	KVA	0	kW
SSR	0	KVA	0	kW
Elliptical	0	KVA	0	kW
CP	3245	KVA	3245	kW
CDS	119	KVA	119	kW
MPS	5	KVA	5	kW
HPRF	11832	KVA	10253	kW
LLRF	27	KVA	24	kW
Magnets	753	KVA	685	kW
Vacuum	71	KVA	63	kW
Controls	102	KVA	100	kW
SS	11	KVA	11	kW
Instrumentation	78	KVA	76	kW
WFE	639	KVA	639	kW
Bldgl	771	KVA	739	kW
BeamCommissioning	0	KVA	0	kW
RingsInst	0	KVA	0	kW
BTLBAL	5	KVA	5	kW
Upgrades	0	KVA	0	kW
Conventional Facilities	3980	KVA	3980	kW

	Power					
By Feeders	**21638**		KVA	**19943**		kW
Feeder 1 (23-1)*	6301		KVA	5419		kW
HB650 Amplifiers		4201	KVA		3612	kW
LG-Upgrade*		2100	KVA		1806	kW
Feeder 2 (23-2)	5518		KVA	4821		kW
HWR Amplifiers		126	KVA		113	kW
SSR1 Amplifiers		244	KVA		220	kW
SSR2 Amplifiers		1513	KVA		1362	kW
LB650 Amplifiers		3635	KVA		3126	kW
Feeder 3 (23-3)	5797		KVA	5713		kW
Racks, other, etc.		1817	KVA		1733	kW
Building Power		3980	KVA		3980	kW
Feeder 4 (23-4)	4022		KVA	3990		kW
Cryoplant Building		-	KVA		-	kW
Cold Box Station		135	KVA		135	kW
Warm Compressor Section		3110	KVA		3110	kW
Network Room/General DAQ		2	KVA		2	kW
UP		-	KVA		-	kW
Compressed Air		206	KVA		175	kW
LCW		567	KVA		567	kW
Controls		2	KVA		2	kW

* Feeder 1 utilizes a parallel feed that doubles the capacity

Choose Amplifer Power Estimate	
CW Beam	Select Dropdown Here

*Pulsed Beam or CW Beam

F37 building option, yes or no	
No	Select Dropdown Here

*F37 option is subject to DCR approval

Additional Requirement Management Documents

- Occasionally additional documents are required for “customer” and “supplier” agreements:
  - PIP-II BI Instrument Air & Nitrogen Usage (ED0012529) ➔ Building Infrastructure Requirements
  - PIP-II BI Water Usage Document (ED0012655) ➔ Building Infrastructure Requirements

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PIP-II Building Infrastructure
Instrument Air and Nitrogen Usage Document

Document number: ED0012529

Table 3-1. Instrument Air End User Usage

Component	Quantity [#]	Unit Consumption [scfm]	Total Consumption [scfm]
RFQ Couplers	4	4	16
HWR Couplers	8	1.67	13.4
SSR1 Couplers	16	3.5	56.0
SSR2 Couplers	35	6.17	216.0
LB650 Couplers	36	6.17	222.1
HB650 Couplers	36	7.03	253.2
Cryomodule JT Control Valves	25	0.141	3.5
Cryomodule CD Control Valves	25	0.066	1.7
Beam and Vacuum Valves	All	0**	0**
CDS			
Tunnel Control Valves	All	-	28.3
Distribution Box Control Valves	All	-	1.4
Cryoplant			
Coldbox Control Valves	All	-	64.9
Warm Compressor System Control Valves	All	-	14.8
Warm Header Control Valves	2	0.2	0.4
Cryoplant ORS and GMP Control Valves	All	-	11.8
Recovery Compressor Control Valves	All	-	0.2
Liquid Helium Dewar Control Valve	1	0.1	0.1

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PIP-II Building Infrastructure
Water Usage Document

Document number: ED0012655

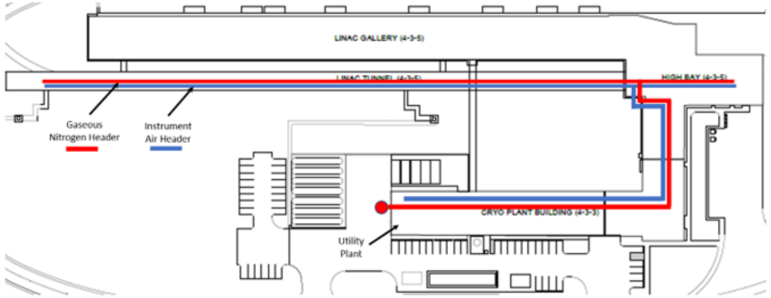


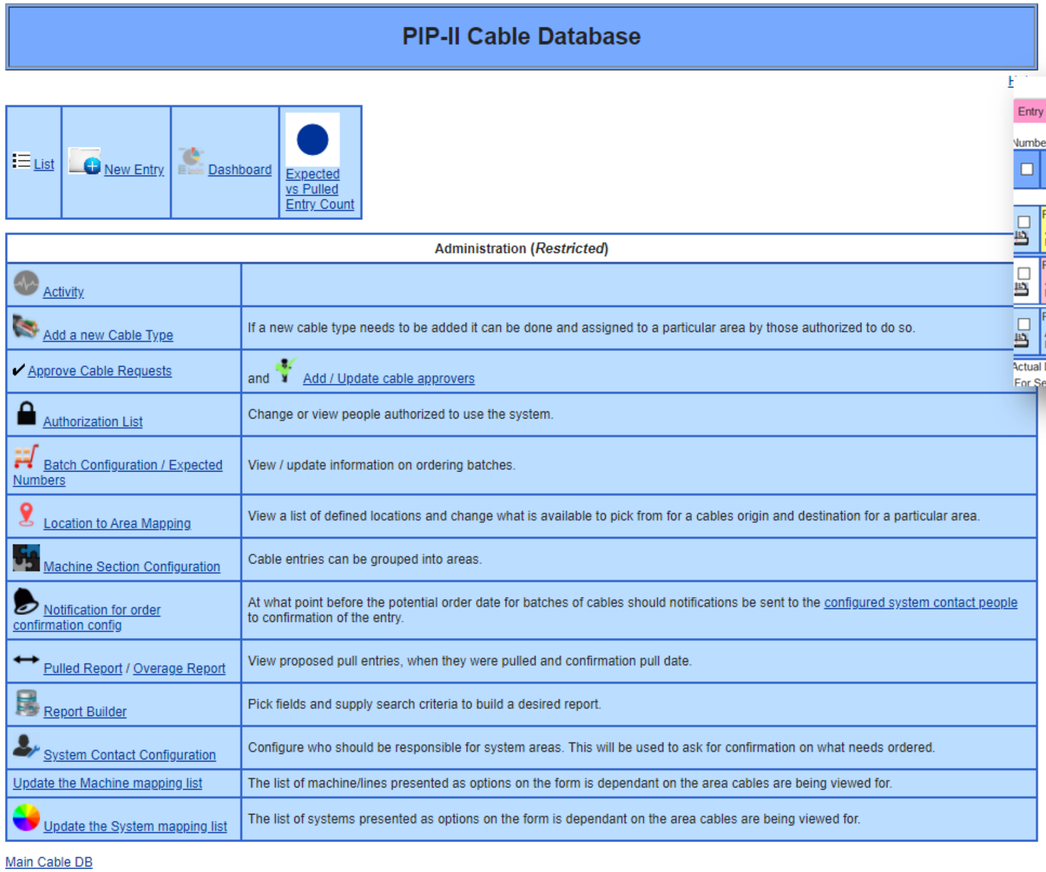
Figure 3-1. LCW System (placeholder)

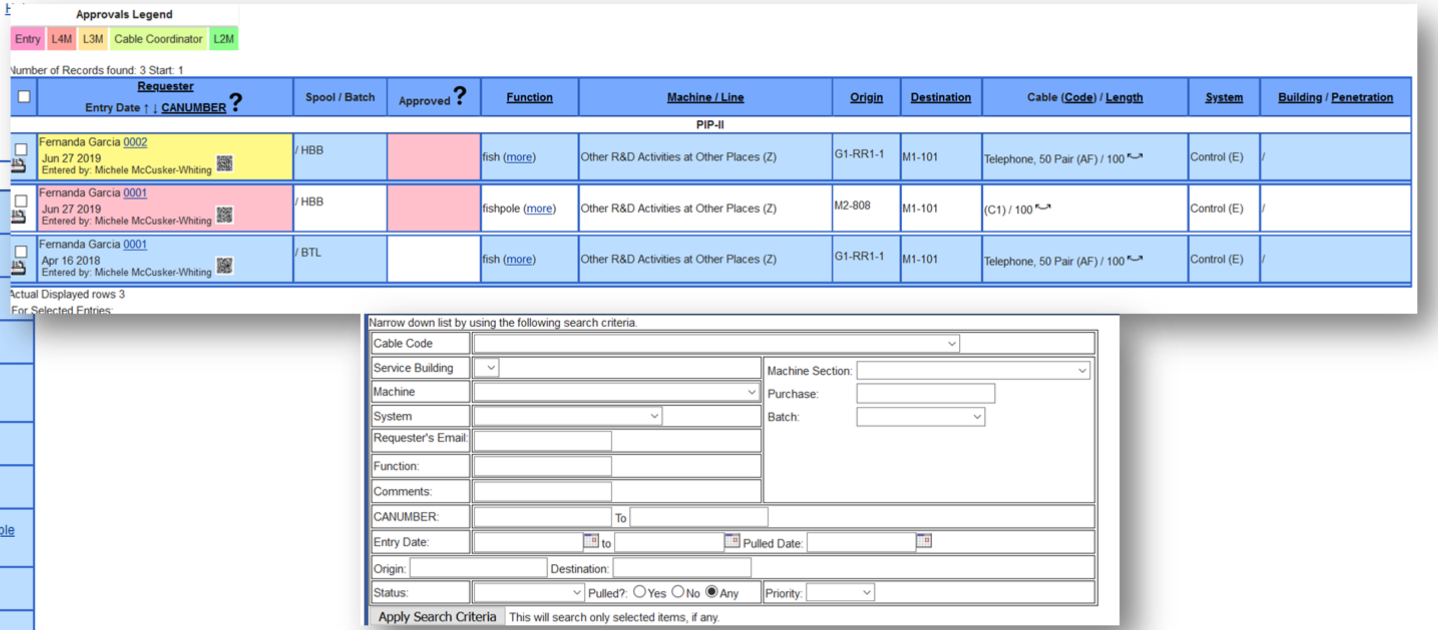
Table 3-1. LCW End User Usage

Component	Quantity [#]	Unit Consumption [gpm]	Total Consumption [gpm]

Additional Requirement Management Documents

- Occasionally additional documents are required for “customer” and “supplier” agreements:
  - PIP-II Cable Database ➔ CF & Building Infrastructure Requirements





Partner Requirements

- Sub-level FRSs (below L3) are managed at the discretion of the system L3M
- Formal requirement management still required for:
  - Partner to L3 collaboration
  - Partner to Partner collaboration
- Assists in controlling design efforts
- Maintains consistent requirement definition and compliance among different components in system

THANK YOU!